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Comparison of posture among adolescent male volleyball players and non-athletes

AUTHOR: Grabara M

Department of Recreation, The Jerzy Kukuczka Academy of Physical Education in Katowice, Poland

Correspondance author:
Małgorzata Grabara
Department of Recreation,
The Jerzy Kukuczka Academy of Physical Education in Katowice,
Poland
E-mail: m.grabara@awf.katowice.pl

ABSTRACT: Due to high training loads and frequently repeated unilateral exercises, several types of sports training can have an impact on the process of posture development in young athletes. The objective of the study was to assess and compare the postures of adolescent male volleyball players and their non-training peers. The study group comprised 104 volleyball players while the control group consisted of 114 non-training individuals aged 14-16 years. Body posture was assessed by the Moiré method. The volleyball players were significantly taller, and had greater body weight and fat-free mass. The analysis of posture relative to symmetry in the frontal and transverse planes did not show any significant differences between the volleyball players and non-athletes. Postural asymmetries were observed in both the volleyball players and the control participants. Lumbar lordosis was significantly less defined in the volleyball players compared to non-training individuals while no difference was observed in thoracic kyphosis. All athletes demonstrated a loss of lumbar lordosis and an increase in thoracic kyphosis. Significant differences in anteroposterior curvature of the spine between the volleyball players and the non-athletes might be associated with both training and body height. Considering the asymmetric spine overloads which frequently occur in sports training, meticulous posture assessment in young athletes seems well justified.

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INTRODUCTION

Physical activity has an impact on the posture and physical development of a young organism. Sports training as a specific form of directional physical activity can exert a significant effect on the process of posture development of young men due to high training loads and repeated unilateral exercises [1, 2]. Volleyball training is aimed, among other things, at improving technical skills, such as ball return, serve, attack or block. Serve and attack comprise a number of asymmetric techniques, which may adversely affect posture. Asymmetric tilt and shift patterns in the shoulder girdle cause muscle imbalance and weakness, thus increasing the risk of shoulder injuries [3], which might, in turn, contribute to spine asymmetry.

Athletes' posture is an area of interest for numerous researchers, all of whom have found that physical training affects body posture. However, there is no consensus on the direction of this effect, which could be due to the fact that studies usually involve groups of athletes quite diverse in age and the sport they practise. Posture development, whether normal or defective, also depends on the sports discipline practised by an individual. Postural defects are defined as asymmetries in the frontal and horizontal planes and abnormal, i.e., deepened or flattened, anteroposterior (AP) spinal curvatures [4].

Asymmetric sports may contribute to the development of asymmetric posture or increase the pre-existing asymmetry. Sports that enforce specific body positions, such as kayaking, rowing, weight lifting (barbells), gymnastics or pair figure skating, cause significant spine overload, which affects the shape of the vertebral column, increases the risk of musculoskeletal disorders and impairs development [5, 6]. It is also believed that athletes with postures deviations may be more susceptible to injuries [7]. Studies on the relationship between posture and sports injuries in footballers showed that back injuries were associated with poor symmetry of shoulders, scapulae abduction and back asymmetry [7].

Several researchers have confirmed that morphological asymmetry in sportsmen, defined as the difference between the right and left part of the body [8, 9], results from specific, mostly asymmetric movements. The need for the evaluation, and if necessary, elimination of such movements is widely recognized [8, 9].

Although sports training might have some disadvantageous effects on posture, it is essential to emphasize the positive influence of physical activity on physical fitness of children and youth, which has been documented by numerous authors [10, 11]. The studies on young football players [4], girl gymnasts [12] and swimmers [13] showed that children who practised sports had better posture than their non-training peers. This seems to confirm the beneficial influence of those sport activities that are predominantly characterized by bilateral motor coordination.

There is definitely a need for posture monitoring in sport [14], especially in young athletes. Previous studies on body posture mostly concerned adult sportsmen. Hence, this study focused on young volleyball players who are still in their developmental period and are therefore more susceptible to postural alterations. Such studies might help establish whether posture development proceeds normally, and, if not, what corrective exercises should be included in the training programmes.

The aim of the present study was 1) to describe habitual posture in young male volleyball players, 2) to compare habitual posture between young male volleyball players and non-athletes and 3) to investigate whether age and anthropometric parameters may affect posture.

MATERIALS AND METHODS

Subjects. The study group comprised 104 volleyball players (V) and the control group 114 male non-athletes (C). Training experience and the frequency of training sessions depended on the participants' age and varied between 2 and 6 years. The volume of training was five 90-minute sessions a week. The subjects were divided into three age groups, i.e., 14-, 15- and 16-year-old boys.

Inclusion and exclusion criteria

Volleyball players were selected based on the following inclusion criteria: minimum 2 years of continuous volleyball training, non-participation in any other sport, parental consent to participate in the study, age 14 to 16 years. For non-training males the inclusion criteria were as follows: non-participation in sport, participation in mandatory physical education classes, parental consent to participate in the study, age 14 to 16 years.

Subjects were excluded from the study in the case of an incomplete application, locomotor organ pathology or lack of parental consent.

Procedures

The study was approved by the Bioethics Committee of the Academy of Physical Education in Katowice, Poland. All adolescents and their parents were presented with a comprehensive description of the aim and methods of the study. Written consent was requested and obtained from all parents, who also completed a questionnaire to provide information on their children's dominant hand, training experience, other forms of physical activity, participation in physical education classes, locomotor organ pathologies or other obstacles to physical activity. Two different questionnaires were developed to explore the characteristics of the volleyball players and non-athletes. Additional information concerning the frequency of training sessions and players' attendance was obtained from volleyball coaches. All study participants were assessed in the morning or early afternoon, before training or the physical exercise class. They were instructed not to eat for at least 2 hours prior to measurements. Subjects were measured barefoot wearing only underwear.

Body height (BH) was measured to the nearest 0.5 cm using medical scales with a mechanical height rod. Body weight (BW), fat mass (FM), body fat percentage (fat %) and fat-free mass (FFM) were measured using the Tanita-410 Body Composition Analyzer (with an accuracy of 0.1 kg and 0.5%). Body mass index (BMI) was calculated based on BH and BW. The Tanita Body Composition Analyzer (Tokyo, Japan) is a device which determines body weight, body fat percentage and mass, fat-free mass and total body water based on bioelectrical impedance analysis (BIA). Relative to a four-compartment model, correlation coefficients for body fat calculated by Tanita were $r = 0.93$ (body fat in kg) and $r = 0.89$ (body fat %) [15].

Posture was analysed by means of a specialised apparatus that utilizes the shadow Moiré technique [16, 17, 18, 19]. The Moiré method provides a 3-dimensional picture of the back and allows an analysis of over 50 posture parameters with an accuracy of 1 mm and 1° [4, 20]. The method, recommended as a measurement tool in physical therapy, is a non-invasive screening test, readily available and inexpensive. Correlation coefficients between the results of roentgenograms and Moiré topography in posture assessment were 0.93-0.96 [21].

Each subject was instructed to adopt a habitual posture. They stood straight on the floor with the eyes and ears in line horizontally, arms relaxed at the side of the body and feet shoulder-width apart. Posture assessment lasted about 5 seconds, which did not cause postural muscle fatigue.

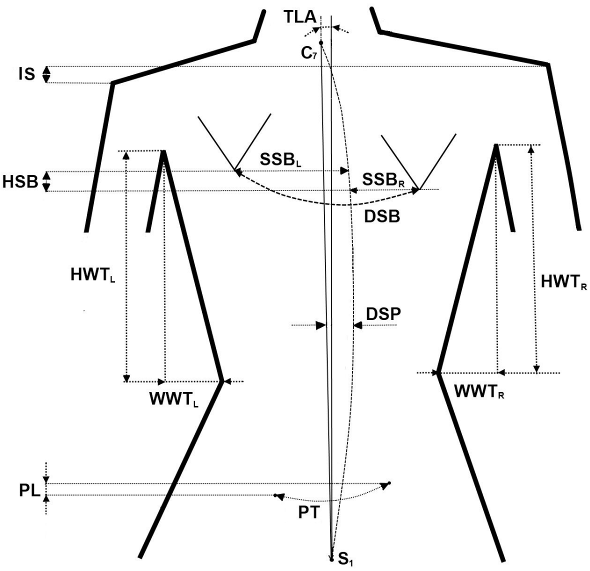

FIG. 1. Diagram of posture in frontal and transverse planes.

The analysis in frontal and transverse planes included:

- torso lateral inclination angle (TLA) [°], the deflection of the C_7-S_1 line from the plumb-line (intersecting the S_1 vertebra) in the frontal plane;
- maximum deflection of the spinous processes from the C_7-S_1 line (DSP) [mm];
- pelvic lateral inclination (PL) [mm] and pelvic torsion (PT) [mm];
- height difference of the waist triangles (HWT) [mm] and width difference of the waist triangles (WWT) [mm];
- height difference of the lower shoulder-blade angles, i.e., inclination (HSB) [mm], depth difference of the lower shoulder-blade angles, i.e., torsion (DSB) [mm] and difference in the distance of the lower shoulder-blade angles from the spine (SSB) [mm];
- inclination of the shoulder line (IS) [mm] (Figure 1).

The analysis in the sagittal plane included:

- torso forward inclination angle (TFA) [°], the deflection of the C_7-S_1 line from the plumb-line (intersecting the S_1 vertebra) in the sagittal plane;
- angular disposition of the upper segment of the thoracic curve – angle α [°],
- angular disposition of the thoracolumbar segment curve – angle β [°],
- angular disposition of the lumbosacral segment curve – angle γ [°],
- thoracic kyphosis angle (ThKA) ($\alpha+\beta$) [°],
- lumbar lordosis angle (LLA) ($\beta+\gamma$) [°].
- compensation coefficient (CC) – thoracic kyphosis angle minus lumbar lordosis angle (ThKA – LLA) (Figure 2).

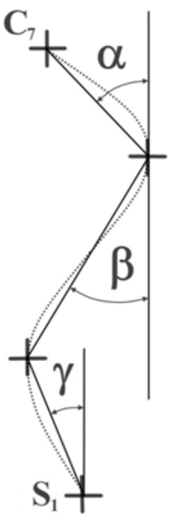

FIG. 2. Diagram of anteroposterior spine curvature angles.

Posture parameters in frontal and transverse planes as well as the TFA were expressed in absolute values (av) showing the magnitude of deflection from the correct alignment (the direction of the deflection was not taken into consideration), and in relative values, informing about the direction of deflection (right-left, front-back). The tables only present absolute values.

Based on the total value of deflections from postural symmetry (i.e., the correct alignment of the spinous processes, shoulders, scapulae, waist triangles and pelvis), a synthetic index of postural symmetry (SIPS) was defined (Table 1).

Statistical analysis

Data analysis included calculating the means and standard deviations (mean±SD) of the variables. The normality of distributions was verified by the Kolmogorov–Smirnov test. The majority of data under analysis did not demonstrate a normal distribution. The Mann-Whitney U test (for non-normal distributions) or the t-test (for normal distributions) was used to analyse differences in posture and anthropometric parameters between athletes and non-training males. The Kruskal-Wallis one-way analysis of variance was used to compare the means of posture characteristics between 14-, 15- and 16-year-old volleyball players and between the corresponding groups of non-athletes. Pearson's r correlation coefficient (linear correlation coefficient) was used to determine the potential effect of somatic development parameters on posture quality. The level of significance was set at $p<0.05$. All statistical analyses were performed using STATISTICA v. 10.0 (StatSoft, USA).

TABLE 1. Criteria for assigning point values to the various postural elements of the body based on the synthetic index of postural symmetry (SIPS).

Calculated parameters	Number of points for the deflections mentioned below						
	< 1	1-2	2.01-3	3.01-5	5.01-10	10.01-15	>15
TLA	0	1	2	3			
DSP	0			1	2	3	4
IS	0				1	2	3
HSB*	0				1	2	3
DSB*							
SSB*							
HWT**	0				1	2	3
WWT**							
PL	0				1	2	3
PT	0				1	2	3
TFA	0	1	2	3			

Legend: TLA – torso lateral inclination angle, DSP – maximum deflection of the spinous process C7-S1, IS – inclination of the shoulder line, HSB – height symmetry of the shoulder blades, DSB – depth symmetry of the shoulder blades in the transverse plane, SSB – symmetry of the shoulder blades from the spine, HWT – height symmetry of the waist triangles, WWT – width symmetry of the waist triangles, PL – pelvic lateral inclination, PT – pelvic torsion, TFA – torso forward inclination angle;
*, ** - parameters for the placement of which there are a maximum of 3 points for the highest-assessed index.

RESULTS

Somatic parameters differed between the volleyball players and non-training group. The volleyball players were significantly taller. They also had greater body weight and fat-free mass. There were no significant differences in BMI or fat mass between the two groups (Table 2).

The analysis of posture relative to symmetry in the frontal and transverse planes did not show any significant differences between the volleyball players and their non-training peers (Table 3).

The largest deflection was observed in the alignment of the scapulae in relation to the transverse plane (DSB) and in the contour of the torso and hip line (HWT, WWT). In both groups, i.e., the volleyball players and non-training subjects, the magnitude of this asymmetry was comparable (Table 3).

Based on the relative magnitude of the deflections, it was found that the posture of right-handed volleyball players (95% of all those studied) and non-training subjects (94% of all those studied) was usually characterized by a slight, left-sided curvature of the spine, left-sided inclination of the torso, left-sided lowering and right-sided torsion of the pelvis. Shoulder girdle alignment in the volleyball players and non-training subjects was as follows:

- the right shoulder was ≥ 5 mm higher than the left one in 37% of the volleyball players and 29% of the non-training participants; 40% of the volleyball players and 45% of the non-training subjects exhibited no asymmetry (difference between shoulder levels of less than 5 mm);
- the left scapula was situated higher than the right one in 45% of the volleyball players and 43% of the non-training subjects;

TABLE 2. Average values (±SD) of anthropometric parameters in adolescent male volleyball players (V) and in non-athletes (C).

Age group	14-year-olds		15-year-olds		16-years-olds		All groups	
Parameters	V (n=28)	C (n=44)	V (n=39)	C (n=41)	V (n=37)	C (n=29)	V (n=104)	C (n=114)
BH [cm]	171.02±6.64*	166.59±8.19	177.99±6.93***	170.7±6.96	181.76±6.58**	176.54±6.28	177.45±7.9***	170.6±8.23
BM [kg]	61.63±11.32	57.89±12.08	67.14±13.27*	61.5±11.33	69.93±15.05*	64.73±8.74	66.65±13.73***	60.92±11.28
BMI [kg·m^{-2}]	21.04±3.6	20.78±3.72	21.06±3.27	21.05±3.38	21.11±4.38	20.79±2.79	21.07±3.75	20.88±3.36
FM [kg]	7.64±6.3	7.68±6.26	9.8±7.76	7.93±6.25	8.69±6.16	7.96±5.48	8.83±6.82	7.84±6.02
FM [%]	11.36±6.77	12.22±7.52	13.44±8.06	12.01±6.71	13.8±14.97	11.72±6.82	13.01±10.74	12.02±7.01
FFM [kg]	54±6.46*	50.2±7.98	57.34±8.11*	52.27±11.12	61.23±11.94***	56.77±5.66	57.83±9.65***	52.62±9.09

Legend: BH – body height, BM – body mass, BMI – body mass index, FM – fat mass, FFM – fat-free mass, *significantly (p<0.05) different from the control group, **significantly (p<0.01) different from the control group, ***significantly (p<0.001) different from the control group.

TABLE 3. Average values (±SD) of postural parameters in adolescent male volleyball players (V) and in non-athletes (C).

Age group	14-year-olds		15-year-olds		16-years-olds		All groups	
Parameters	V (n=28)	C (n=44)	V (n=39)	C (n=41)	V (n=37)	C (n=29)	V (n=104)	C (n=114)
TLA [°]	1±0.95	0.98±0.79	1.22±0.86	1.19±0.95	1.17±0.7	1.14±0.85	1.14±0.83	1.1±0.86
DSP [mm]	5.62±2.28	4.54±2.64	4.71±2.23	5.19±2.9	5.2±3.05	4.76±3.3	5.13±2.56	4.83±2.9
PL [mm]	2.2±1.7	1.58±1.56	2.33±1.78	1.87±1.83	2.07±2.18	2.61±2.33	2.21±1.9	1.95±1.91
PT [mm]	6.68±6.39	6.41±4.36	8.48±5.4	8.96±6.05	8.02±5.46	10.83±5.87	7.83±5.69	8.45±5.65
HWT [mm]	8.43±8.1	10.87±7.43	9.12±6.97	10.22±7.74	9.53±8.65	8.6±9	9.08±7.84	10.06±7.94
WWT [mm]	10.36±6.21	10.57±8.33	10.56±7.74	8.95±7.05	12.59±7.15	12.09±8.39	11.23±7.15	10.37±7.93
HSB [mm]	8.38±6.58	7.44±4.7	8.24±5.76	9.25±7.18	9.89±6.76	10.28±9.93	8.87±6.34	8.81±7.24
DSB [mm]	13.02±10.72	12.84±7.4	17.32±9.04	16.75±7.77	17.13±11	18.4±10.32	16.09±10.3	15.66±8.6
SSB [mm]	10.23±6.38	8.05±5.7	8.17±6.12	7.51±6.12	6.74±5.37	6.35±6.97	8.21±6.04	7.42±6.17
IS [mm]	7.26±7.06	6.18±3.93	6.87±5.76	6.66±4.49	6.69±4	7.04±5.33	6.91±5.57	6.57±4.49
SIPS [pts]	10.07±3.28	9.66±1.9	10.26±2.92	10.37±2.93	10.05±2.3	10.41±2.9	10.13±2.79	10.11±2.57
TFA [°]	2.5±1.67	2.65±1.68	2.43±1.66	2.63±2.17	2.22±1.74	2.14±1.43	2.38±1.68	2.51±1.81
a angle [°]	15.58±4.52	14.72±4.02	16.54±4.5	15.77±3.36	15.84±4.98	16.31±3.66	16.03±4.66	15.5±3.73
β angle [°]	14.58±3.11	14.18±2.69	14.55±2.31	14.55±2.88	14.4±2.3	14.27±2.63	14.5±2.52	14.34±2.72
γ angle [°]	9.58±4.7**	14.32±5.95	9.47±5.28*	12.48±6.35	8.13±5.04*	9.89±4.02	9.02±5.04***	12.53±5.89
ThKA [°]	30.16±5.83	28.9±4.86	31.09±5.57	30.32±4.71	30.24±5.9	30.58±5.55	30.54±5.72	29.84±5
LLA [°]	24.16±5.49**	28.5±7.13	24.02±5.84*	27.03±6.74	22.52±5.25	24.16±3.67*	23.53±5.54***	26.87±6.55
CC [°]	6±6.19***	0.4±6.96	7.07±6.33*	3.42±7.58	7.72±7.38	6.42±6.09	7.01±6.66***	3.02±7.33

Legend: TLA – torso lateral inclination angle, DSP – maximum deflection of the spinous process C7-S1, PL – pelvic lateral inclination in the frontal plane, PT – pelvic torsion in the transverse plane, HWT – height symmetry of the waist triangles, WWT – width symmetry of the waist triangles, HSB – height symmetry of the shoulder blades, DSB – depth symmetry of the shoulder blades in the transverse plane, SSB – symmetry of the shoulder blades from the spine, IS – inclination of the shoulder line, SIPS – synthetic index of postural symmetry, TFA – torso forward inclination angle, ThKA – thoracic kyphosis angle ($\alpha+\beta$), LLA - lumbar lordosis angle ($\beta+\gamma$); CC - compensation coefficient (ThKA–LLA);
*significantly (p<0.05) different from the control group, **significantly (p<0.01) different from the control group, ***significantly (p<0.001) different from the control group.

34% of the study participants did not exhibit any asymmetry;
- the right scapula was more protruding than the left one in the majority of study participants, i.e. 81% of the volleyball players and 85% of the non-training individuals;
- the right scapula was further away from the spine than the left one in 46% of the volleyball players and 39% of non-athletes. Scapular symmetry was seen in 36% of the volleyball players and 44% of non-athletes.

A comparative analysis of sagittal spinal curvatures indicated significant differences between the volleyball players and non-training peers. The volleyball players exhibited a significantly lower lumbosacral inclination angle and lumbar lordosis angle (LLA) as well as a significantly higher compensation coefficient (CC), evidencing a loss of lumbar lordosis and an increase in thoracic kyphosis. Nevertheless, the thoracic kyphosis angle (ThKA) was not significantly different between the training and non-training subjects (Table 3).

Kruskal-Wallis one-way ANOVA did not reveal any significant age-dependent differences in posture parameters of the volleyball players. However, the following parameters differed significantly between the age groups of non-training individuals: PT ($p=0.004$), DSB ($p=0.016$), γ angle ($p=0.003$), LLA ($p=0.013$), CC ($p<0.001$). These results indicate that the magnitude of pelvic torsion, scapular asymmetry and compensation coefficient tends to increase with age in non-training subjects, while the γ angle and LLA show the opposite tendency.

An analysis of the correlations between anthropometric parameters and postural characteristics performed separately for the volleyball players ($n = 104$) and non-athletes ($n = 114$) showed the following relationships in both the volleyball players and the control groups:
- Body height correlated with the γ angle (-0.27 in the volleyball players and -0.22 in non-athletes) and LLA (-0.24 and -0.25, respectively),
- Body mass correlated with PT (0.2 and 0.32, respectively).

DISCUSSION

The aim of the present study was to assess, describe and compare body postures of volleyball players and their non-training peers. Somatic parameters of both groups were also compared as they may affect body posture. Potential correlations between somatic parameters and posture characteristics were also evaluated.

Somatic parameters differentiated training and non-training groups with respect to body height, weight, and fat-free mass. Greater body height should be expected as a result of the selection process. However, there was a surprising lack of significant differences in BMI and fat mass although volleyball players should not only be tall, but also slim.

Age did not affect posture in the volleyball players, indicating that training duration did not have negative influence on posture quality. However, this study did indicate a tendency to age-related pelvic and scapular asymmetry and flattening of the lumbar lordosis in the non-training subjects, which might have been associated with the pubertal growth spurt. Previous studies revealed that the frequency of posture defects and their persistence increased with sexual maturation and a decrease in physical fitness [18, 22]. Correlation analysis revealed that taller subjects had smaller lordotic angles compared to the other participants, which seems to confirm the above-mentioned findings. Also, subjects with greater body weight more frequently exhibited pelvic asymmetry.

Postural asymmetries were observed in both the volleyball players and the non-training subjects. The largest asymmetries were observed in scapulae alignment relative to the transverse plane and waist triangles. The relatively large DSB values could be accounted for by asymmetric detachment of the scapulae that could have resulted from habitual torsion of the torso while asymmetries of waist triangles might indicate lateral curvatures of the spine. The average deflection of the spinous processes line in all subjects seems to evidence slight lateral curvatures of the spine (5-10 mm deflection). Hence, posture asymmetries might result from habitual behaviours related to lateralization. The majority of the study participants exhibited a slight, left-sided curvature of the spine and similar alignment of other posture elements. Right-handed male volleyball players had left-sided lowering and right-sided torsion of the pelvis, as well as a lower and more protruding right scapula. The study of Vařeková et al. (2011) demonstrated a “typical” postural pattern in 81% of the right-handed elite female volleyball players, in whom the acromion, scapula and iliac crest were in a higher position on the left side than on the right [23]. The pattern was different than that observed in adolescent male volleyball players of this study.

Other studies comparing the postures of athletes and non-training subjects also demonstrated several asymmetries. Table tennis players showed more asymmetries in the alignment of the shoulders, scapulae and waist triangles compared to their non-training counterparts. The authors suggested it could be related to intensive and one-sided trunk muscle work [19]. When comparing the results of body posture assessment in tennis and volleyball players, it should be noted that training specificity of both sports is different. Table tennis is a laterally dominant sport whereas volleyball includes both asymmetric and symmetric elements.

Boys practising athletics training (running) exhibited waist triangle asymmetries more frequently than their non-training peers [24], although running is a sports discipline which requires bilateral integration exercises. By contrast, a study on the posture of young male football players and non-training peers demonstrated that, within the training group, frontal plane pelvic alignment as well as the waist triangles were, in fact, frequently correct, whereas some abnormalities were observed in transverse plane pelvic and scapulae alignment [4].

Based on the findings of the present study and those of other researchers, it can be hypothesized that the severity and magnitude of posture asymmetries are related to the character of a particular sports discipline or competition. Even for athletes practising similar sports, e.g., team games, body posture can vary in the magnitude and frequency of asymmetry. Although posture asymmetries are commonly seen in both athletes and non-training subjects, their development should not be underestimated. It is important to strive for symmetry in the training process, and regularly monitor the degree of asymmetry in order to avoid potential injuries and maximize athletic efficiency [9]. It might also be advisable to implement individually tailored compensatory exercises and stretching or yoga exercises for all athletes [23, 25].

Volleyball is a sport with a predominance of forward-bending and extension postures. This type of position has been associated with alterations in the sagittal spinal curvature [26]. The present evaluation of posture in the sagittal plane revealed significant differences in the shape of the spine, and particularly its lower portion. Volleyball players had a lower degree of lordosis than non-athletes, and the compensation coefficient (CC) demonstrated that thoracic kyphosis was greater than lumbar lordosis. No significant differences were observed regarding the angle of thoracic kyphosis in the volleyball players and non-training subjects. It has been noted though that tallness favours flattening of lumbar lordosis. Flattened lumbar lordosis can also be associated with pelvic retroversion due to increased activation of trained abdominal and gluteal muscles.

The majority of researchers confirm the influence of sports training on the shape of vertebral curvatures [6, 17, 27]. Uetake et al. argued that the formation of the AP curvatures depended on the specificities of sports disciplines. They found that sprinters, runners, jumpers, kendo participants and throwers had a deep spinal curvature, whereas swimmers, bodybuilders, sailors, soccer players, rugby players and non-athletes had a shallow curvature [17]. Results of posture evaluation among the representatives of different sports indicated that thoracic kyphosis was greater than lumbar lordosis (kyphotic type of posture) in both volleyball and handball players, whereas sprinters and taekwondo competitors exhibited a balanced posture type [28].

The evaluation of the shape of the spine at different postures in elite cyclists and non-athletes showed greater thoracic curvature in cyclists while standing [29]. López-Minarro et al. reported similar findings in canoeists [30]. Based on the evaluation of spinal curvatures in young elite skiers, Alricsson and Werner reported increased thoracic kyphosis but no change in lumbar lordosis [31]. Förster et al. observed increased thoracic kyphosis and lumbar lordosis in elite climbers [32]. Wodecki et al. found more pronounced lumbar lordosis and flattened thoracic kyphosis in soccer players compared to non-training subjects [33]. López-Minarro et al. observed that lumbar lordosis was more flattened in young elite paddlers than in non-athletes [34]. Muyor et al. concluded that tennis did not alter sagittal spinal morphology in the relaxed standing posture in adolescent male and female players [26].

To sum up, the shape of AP curvatures in the sagittal plane may depend on sport specificities. However, correlations of AP curvatures with body height do not provide clear evidence regarding the impact of volleyball training on sagittal plane postures. Significant differences in AP curvatures between volleyball players and non-athletes might be associated with training and body height.

Limitations of the study

The non-training individuals differed from the volleyball players with respect to somatic parameters, which is not surprising considering the fact of random selection of the non-athlete participants. Nevertheless, the study findings seem to unambiguously confirm the effect of regular volleyball training on body posture.

CONCLUSIONS

In conclusion, volleyball training does not negatively affect the posture of the training subjects. Postural asymmetries observed in both the volleyball players and non-training peers might have resulted from lateralization. The most common asymmetries were those in the position of the scapulae and waist triangles. Asymmetries in transverse plane pelvic alignment have been less frequently reported in volleyball players than in non-athletes.

Volleyball players demonstrated a loss of lumbar lordosis and an increase in thoracic kyphosis more frequently than their non-training peers, whereas the angle of thoracic kyphosis did not differ between athletes and non-training subjects.

Considering the asymmetric spine overloads which frequently occur in sports training, we strongly recommend posture assessment in young athletes. If necessary, exercises that help maintain good posture should be included in training sessions.

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REFERENCES

1. Hawrylak A, Skolimowski T, Barczyk K, Bieć E. Asymmetry of trunk in athletes of different kind of sport. Polish J Sport Med. 2001;17:232-235.
2. Wojtys EM, Ashton-Miller JA, Huston LJ, Moga PJ. The association between athletic training time and the sagittal curvature of the immature spine. Am J Sports Med. 2000;28:490-498.
3. Wang HK, Cochrane T. Mobility impairment, muscle imbalance, muscle weakness, scapular asymmetry and shoulder injury in elite volleyball athletes. J Sport Med Phys Fit. 2001;41:403-410.
4. Grabara M. Analysis of body posture between young football players and their untrained peers. Hum Mov. 2012;13(2):120-126.
5. Baranto A, Hellström M, Cederlund C, Nyman R, Sward L. Back pain and MRI changes in the thoraco-lumbar spine of top athletes in four different sports: a 15-year follow-up study. Knee Surg Sports Traumatol Arthrosc. 2009;17:1125-1134.
6. López-Miñarro PA, Muyor JM, Alacid F. Sagittal spinal curvatures and pelvic tilt in elite young kayakers. Med Sport. 2010;63(4):509-519.

7. Watson AW. Sports injuries in footballers related to defects of posture and body mechanics. J Sport Med Phys Fit. 1995;35(4):289-294.
8. Dorado C, Sanches Moysi J, Vicente G, Serrano JA, Rodriguez LP, Calbet JAL. Bone mass, bone mineral density and muscle mass in professional golfers. J Sports Sci. 2002;20:591-597.
9. Krzykała M. Dual energy X-ray absorptiometry in morphological asymmetry assessment among field hockey players. J Hum Kinet. 2012;25(1):77-84.
10. Boreham C, Riddoch C. The physical activity, fitness and health of children. J Sports Sci. 2001;19:915- 929.
11. Tittlbach SA, Sygusch R, Brehm W, Woll A, Lampert T, Abele AE, et al. Association between physical activity and health in German adolescents. Eur J Sport Sci. 2011;11(4):283-291.
12. Grabara M. Postural variables in girls practicing sport gymnastic. Biomed Hum Kinet. 2010;2:74-77.
13. Maćkowiak Z, Wiernicka M. Body posture in girls aged 13-18 involved in synchronized swimming. Polish J Sport Med. 2010;26:115-122.
14. Hennessey L, Watson AW. Flexibility and posture assessment in relation to hamstring injury. Br J Sports Med. 1993;27:243-246.
15. Jebb S, Cole T, Doman D, Murgatroyd P, Prentice A. Evaluation of the novelTanita body-fat analyser to measure body composition by comparison with a four-compartment model. Br J Nutr. 2000;83:115-122.
16. Drzał-Grabiec J, Snela S. The influence of rural environment on body posture. Ann Agr Env Med. 2012;19(4):846-850.
17. Uetake T, Ohsuki F, Tanaka H, Shindo M. The vertebral curvature of sportsmen. J Sports Sci. 1998:621-628.
18. Wilczyński J. The most common faulty postures among boys aged 13–16 years measured by moire's photogrametric method. Med Pr. 2006;57(4):347-352.
19. Barczyk-Pawelec K, Bańkosz Z, Derlich M. Body postures and asymmetries in frontal and transverse planes in the trunk area in table tennis players. Biol Sport. 2012;29:129-134.
20. Grabara M. A comparison of the posture between young female handball players and non-training peers. J Back Musculoskelet Rehabil. 2014;27(1):85-92.
21. El-Sayyad MM. Comparison of roentgenography and moiré topography for quantifying spinal curvature. Phys Ther. 1986;66:1078-1082.
22. Proszkowiec M, Słonka K, Hyla-Klekot L. Formation of body posture in the 2nd critical stage of postural development with regard to sexual maturity of subjects. Fizjoterapia. 2011;19(1):10-19.
23. Varekova R, Vareka I, Janura M, Svoboda Z, Elfmark M. Evaluation of Postural Asymmetry and Gross Joint Mobility in Elite Female Volleyball Athletes. J Hum Kinet. 2011;29:5-13.
24. Grabara M, Hadzik A. The body posture in young athletes compared to their peers. Polish J Sport Med. 2009;25(2):115-124.
25. Grabara M, Hadzik A. Postural variables in girls practicing volleyball. Biomed Hum Kinet. 2009;1:67-71.
26. Muyor JM, Sanchez-Sanchez E, Sanz-Rivas D, López-Miñarro PA. Sagittal Spinal Morphology in Highly Trained Adolescent Tennis Players. J Sports Scie Med. 2013;12:588-593.
27. Rajabi R, Doherty P, Goodarzi M, Hemayattalab R. Comparison of thoracic kyphosis in two groups of elite Greco-Roman and freestyle wrestlers and a group of non-athletic participants. Br J Sports Med. 2008;42:229–232.
28. Lichota M, Plandowska M, Mil P. The shape of anterior-posterior curvatures of the spine in athletes practising selected sports. Polish J Sport Tourism. 2011;18:112-121.
29. Muyor JM, López-Miñarro PA, Alacid F. A comparison of the thoracic spine in the sagittal plane between elite cyclists and nonathlete subjects. J Back Musculoskelet Rehabil. 2011;24(3):129-135.
30. López-Miñarro PA, Muyor JM, Alacid F. Sagittal spinal and pelvic postures of highly-trained young canoeists. J Hum Kinet. 2011;29:41-48.
31. Alricsson M, Werner S. Young elite cross-country skiers and low back pain. A 5-year study. Phys Ther Sport. 2006;7:181-184.
32. Förster R, Penka G, Bösl T, Schöffl V. Form and Mobility of the Thoracolumbar Spine Leading to Postural Adaptations in Male High Ability Rock Climbers. Int J Sports Med. 2009;30:53-59.
33. Wodecki P, Guigui P, Hanotel MC, Cardinne L, Deburge A. Sagittal alignment of the spine: comparison between soccer players and subjects without sports activities. Rev Chir orthop Reparatrice Appar Mot. 2002;4:328-336.
34. López-Miñarro P, Alacid F, Rodriguez P. Comparison of sagittal spinal curvatures and hamstring muscle extensibility among young elite paddlers and non-athletes. Int SportMed J. 2010;11(2):301-312.